RADIO APPARATUS

This invention relates to radio apparatus and in particular to radio apparatus with a dual antenna configuration.

As electronics and communications technologies have advanced, there has been a drive to increase the performance and decrease the size of consumer devices. In particular, in the field of mobile communications there has been continual demand for increasingly smaller communications devices, such as telephones, computers and personal organisers, but without a decrease in performance.

One area in which size design goals may be counter to performance design goals is in the design of antennae. Typically a mobile communication device, such as a radiotelephone, is provided with a rod, otherwise known as a whip, antenna or a helix, otherwise known as a stub, antenna.

To minimise space requirements the type of antenna used by the radiotelephone, be it a rod or helix antenna, is a monopole antenna. The monopole antenna acts as a conductor placed above a ground plane in the radiotelephone, typically the printed circuit board (PCB). The conductor forms an image in the ground plane such that the resulting antenna pattern is a composite of the 'real' antenna (i.e. the monopole antenna) and the 'image' antenna (i.e. the image in the ground plane). However, when using the radiotelephone ground plane as an 'image' antenna the performance of the antenna is more susceptible to user interaction. Also, potentially the complexity of the PCB design is increased and impedance bandwidth can be reduced.

To ensure adequate antenna performance when a radiotelephone is in both standby and operational mode it has become common place for radiotelephones to have both a rod antenna and a helix antenna. The antennae are arranged so that the helix antenna is coupled to a transceiver when the rod antenna is in its retracted position with the rod antenna being decoupled from the transceiver. In this configuration the helix antenna uses the radiotelephone ground plane as the 'image' antenna. When the rod antenna is extended the rod antenna is coupled to the transceiver and the helix antenna is decoupled from the transceiver. In this configuration the rod antenna uses the radiotelephone ground plane as the 'image' antenna. Thereby the radiotelephone is able to monitor base station messages when in standby without the need for the rod antenna to be extended so minimising the risk of damage to the rod antenna. However, when a call is established between a basestation and the radiotelephone to obtain increased antenna performance the rod antenna is extended. However, even though the helix is less susceptible to damage than an extended rod antenna the helix is still exposed and susceptible to damage. Further, as a helix antenna extends from a radiotelephone the antenna can detract from the appearance of the radiotelephone.

In accordance with an aspect of the present invention there is provided radio apparatus comprising a housing; a first antenna mounted within the housing such that the first antenna is enclosed by the housing; and a second antenna arranged to extend away from the housing, wherein the first and second antenna are electrically coupled.

By coupling the first antenna, i.e. an internal antenna, and second antenna, i.e. an external antenna, the first and second antenna act as a balanced antenna. That is to say, the extended antenna acts as one pole of a dipole antenna and the internal antenna acts as the other pole of the dipole antenna.

This minimises the need to use the radio apparatus ground plane. This has the advantage of less user interaction, less board size dependence, higher radiation efficiency and a higher impedance bandwidth.

By minimising the use of the ground plane the electrical losses associated with using the ground plane to balance the radio apparatus antenna are minimised. Further, by minimising the current flowing through the ground plane this minimises the coupling between the radio apparatus and the user.

Preferably the second antenna is extendible from the housing such that upon extension of the second antenna from the housing the first and second antenna are electrically coupled.

Suitably the second antenna is movable between a retracted position and an operable position such that the first antenna and second antenna are electrically coupled when the second antenna is in its operable position. The first antenna and second antenna are electrically decoupled when the second antenna is in its retracted position.

Preferably the first antenna and second antenna are arranged to provide different radiation areas to provide polarisation diversity for a received signal. This provides the advantage of removing the need for an additional diversity antenna.

Preferably the first antenna is internally mounted within the upper portion of the housing, as presented to a user during operation of the radio apparatus. As radio apparatus, for example radiotelephones, are designed to be held by the lower portion of the housing this further minimises the user interaction with the signal transmitted or received by the antennae.

Suitably the first antenna is tuned to the receive frequency of a signal, thereby being optimised to receive signals.

Preferably the second antenna is arranged so that in its operable position the second antenna is angled away from a user during operation of the radiotelephone. This further minimises user interaction with the radio apparatus.

Preferably the upper end of the second antenna is substantially flush with the exterior of the housing when the second antenna is in its retracted position.

For a better understanding of the present invention and to understand how the same may be brought into effect reference will now be made, by way of example only, to the accompanying drawings, in which:-

Figure 1 shows radio apparatus in accordance with a first embodiment of the present invention with an extended whip antenna;

Figure 2 shows radio apparatus in accordance with the first embodiment of the present invention with a retracted whip antenna;

Figure 3 shows a dual antenna configuration in accordance with a second embodiment of the present invention;

Figure 4 shows radio apparatus in accordance with a third embodiment of the present invention;

Figure 5 shows a dual antenna configuration in accordance with an embodiment of the present invention;

Figure 6 shows a typical impedance bandwidth of a planar antenna using the ground plane of a radiotelephone;

Figure 7 shows the impedance bandwidth for a dual antenna configuration in accordance with the present invention;

Figure 8 shows the impedance bandwidth for a tuned dual antenna configuration in accordance with the present invention

Figure 9 shows a dual antenna configuration in accordance with an embodiment of the present invention;

Figure 10 shows a dual antenna configuration in accordance with an embodiment of the present invention;

Figure 11 shows an extendable coiled whip antenna in accordance with the present invention in its retracted position;

Figure 12 shows an extendable coiled whip antenna in accordance with the present invention in its extended position;

Figure 13 shows an extendable telescopic whip antenna in accordance with the present invention in its extended position;

Figure 14 shows an extendable whip antenna in accordance with the present invention in its extended position positioned away from a user;

Figure 15 shows an embodiment of an extendable whip antenna in accordance with the present invention in its retracted position;

The radiotelephone 1 of figure 1 includes a housing 2 within which is mounted a printed circuit board (PCB) 3 on which is located the electronic components of the radiotelephone 1, which includes a transceiver 4 for receiving and transmitting a signal. The housing 2 includes a user interface (not shown) to allow a user to operate the radiotelephone.

Also mounted within the housing 2 is an internal antenna 5, typically a planar inverted F antenna. The internal antenna 5 is coupled to the transceiver 4, typically via the PCB 3 as described below.

Associated with the housing 2 is an antenna that extends away from the housing. For example, in one embodiment a whip antenna 6 that is extendable from the housing as shown in figure 1, and in a second embodiment a helix antenna that is mounted on the housing, as shown in figure 4. The preferred embodiment, however, is the whip antenna, which is movable between an extended position, as shown in figure 1, and a retracted position, as shown in figure 2.

In the first embodiment, as shown in figure 1 and 2, a coupling member 7 is coupled to the internal antenna 5. The coupling member 7 is arranged to electrically couple the whip antenna 6 to the internal antenna 5 when the whip antenna 6 is in its extended position and electrically decouple the whip antenna 6 from the internal antenna 5 when the whip antenna is in its retracted position. One embodiment of this coupling is shown in figure 3.

As shown in figure 3, the internal antenna 5 is coupled to coupling member 7 via a live feed 10. The coupling member 7 comprises an electrically conducting cylinder through which is inserted the whip antenna 6. The whip antenna 6 has a protective insulating layer extending over the whole area of the resonator element with a conducting element 15 coupled to the resonator

element attached at the lower end of the whip antenna 6. When the whip antenna 6 is in its extended position, as shown in figure 1, the whip antenna 6 is electrically coupled, via the coupling member 7 and live feed 10, to the internal antenna 5. When the whip antenna 6 is in its retracted position the whip antenna 6 is electrically decoupled from the coupling member 7. The transceiver 4 is electrically coupled to the live feed 10 at point A.

The second embodiment, comprising an helix antenna as shown in figure 4, has the internal antenna 5 and helix antenna 16 coupled, via live feed 10, to the transceiver at point A.

The two antennae for either embodiment can, however, be electrically coupled by galvanic, capacitive or inductive means.

The internal antenna and associated extended antenna are designed to provide a substantially balanced antenna.

In the embodiments shown in figure 1 and 4 the antenna 6, 16 and internal antenna 5 are arranged to operate with radiating edges polarised orthogonal to each other. In this configuration the antennae operate to provide polarisation diversity. This avoids the need for an extra diversity antenna within the radiotelephone.

As shown in figure 5, the internal planar antenna 5 comprises a flat conductive sheet 8 supported above a reference voltage plane 3 such as a ground plane, typically the PCB. The sheet 8 is separated from the reference voltage plane 3 by an air dielectric or supported by a solid dielectric. A corner of the sheet is coupled to the ground via a grounding stub 9 and a feed 10 is coupled to an edge of the flat sheet 8 adjacent the grounded corner. In this

embodiment the whip antenna 6 is coupled, via the coupling member 7, to the end of the live feed of the internal antenna 5 adjacent the sheet 8.

The internal planar antenna 5 forms a resonant circuit having a capacitance and inductance per unit length. The feed point is positioned on the sheet a distance from the corner such that the impedance of the antenna at that point matches the output impedance of the feed line, which is typically 50 ohms. The main mode of resonance of the planar antenna is between the short circuit and the open circuit edge. Thus the resonant frequency supported by the planar antenna is dependent on the length of the sides of the sheet and to a lesser extent the distance and the thickness of the sheet.

For radio frequencies used by cellular telecommunication systems the size of the planer antenna is relatively small, thus allowing the antenna to be mounted within the radiotelephone housing. By placing the antenna inside the housing this has the advantage that the antenna does not distract from the overall aesthetic appearance of the radiotelephone and the antenna is less likely to be damaged.

The internal antenna 5 is typically slightly biased to the radiotelephone receive frequency of the telecommunication cellular system with which the radiotelephone is registered with. Thus when the extendable antenna 6 is in its retracted position and disconnected from the transceiver 4 the internal antenna 5 is optimised to receive messages from the cellular system.

The impedance bandwidth of an antenna is calculated as follows:

$$B_Z = B_{-6dB} / f_0 \times 100\%$$

where

B_z is the impedance bandwidth;

B_{-6dB} is the bandwidth at 6dB; and

f_0 is the centre frequency.

The impedance bandwidth of a typical internal planar antenna using the ground plane of the radiotelephone to form an image is shown in figure 6. Therefore, the impedance bandwidth is of the order of 150MHz /1GHz x 100%, i.e. 15%.

The impedance bandwidth of the internal planar antenna 5 and whip antenna 6 when coupled is shown in figure 7. This configuration provides almost 300MHz of bandwidth at 1GHz i.e. 30%, double the impedance bandwidth of the internal antenna using the ground plane as the antenna image. The bandwidth can be extended further by tuning the antenna combination, for example by using two matching capacitors (not shown), one in series the other shunt, the impedance bandwidth can be extended to 350MHz at 1GHz, as shown in figure 8, i.e. 35%.

Examples of other implementations of the electrical coupling of the extended antenna 6, 16 and internal antenna 5 are shown in figure 9 and figure 10. Figure 9 shows the extended antenna 6 coupled to the edge of the live feed of the internal antenna 5 adjacent the ground plane 3. Figure 10 shows the extended antenna directly coupled to the internal antenna sheet 8.

As the extendable antenna is located separately to the internal antenna this offer greater flexibility in the type and positioning of the extendable antenna. Figure 11 and 12 show the extendable antenna as a coiled whip antenna 11 which in its retracted position is coiled around itself. Figure 13 shows the extendable antenna as a telescopic antenna 12. Figure 14 shows the extendable antenna 13 being able to extend at an angle away from a user to further minimise user interaction with the radiotelephone, thereby further enhancing the performance of the radiotelephone.

Further, as an additional helix antenna is not required, the tip 14 of the extendable antenna 13 can be designed to fit flush with the housing when the antenna is in its retracted position, as shown in figure 15. Thus, enhancing the aesthetic appearance of the radiotelephone when the whip antenna is in its retracted position.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the claims.

CLAIMS

1. Radio apparatus comprising a housing; a first antenna mounted within the housing such that the first antenna is enclosed by the housing; and a second antenna arranged to extend away from the housing, wherein the first and second antenna are electrically coupled.

2. Radio apparatus according to claim 1, wherein the second antenna is extendible from the housing such that upon extension of the second antenna from the housing the first and second antenna are electrically coupled.

3. Radio apparatus according to claim 1, wherein the second antenna is movable between a retracted position and an operable position such that the first antenna and second antenna are electrically coupled when the second antenna is in its operable position.

4. Radio apparatus according to claim 1 or 2, wherein the first antenna and second antenna are electrically decoupled when the second antenna is in its retracted position.

5. Radio apparatus according to any of the preceding claims, further comprising a transceiver mounted within the housing for transmitting a signal and receiving a signal via the first and/or second antenna.

6. Radio apparatus according to any of the preceding claims, wherein the first antenna and second antenna are arranged to provide polarisation diversity for a received signal.

7. Radio apparatus according to any of the preceding claims, wherein the first antenna is a planar antenna.

8. Radio apparatus according to any of the preceding claims, wherein the first antenna is internally mounted within the upper portion of the housing, as presented to a user during operation of the radio apparatus.

9. Radio apparatus according to any of the preceding claims, wherein the first antenna is tuned to the receive frequency of a signal.

10. Radio apparatus according to any of the preceding claims, wherein the second antenna is a telescopic whip antenna.

11. Radio apparatus according to any of claims 1 to 9, wherein the second antenna is a coiled whip antenna.

12. Radio apparatus according to any of the preceding claims, wherein the second antenna is arranged so that in its operable position the second antenna is angled away from a user during operation of the radiotelephone.

13. Radio apparatus according to any of the preceding claims, wherein the upper end of the second antenna is substantially flush with the exterior of the housing when the second antenna is in its retracted position.

14. Radio apparatus according to any of the preceding claims, wherein the first antenna and the second antenna operate substantially as a balanced antenna.

15. Radio apparatus according to claim 1, wherein the second antenna is a helix antenna.

16. A radiotelephone comprising a housing; a first antenna mounted within the housing such that the first housing is enclosed by the housing; and a second antenna arranged to extend away from the housing, wherein the first and second antenna are electrically coupled.

17. A radio apparatus substantially as hereinbefore described with reference to the accompanying drawings, and/or as shown therein.

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Application No: GB 9908954.2 **Examiner:** Russell Maurice
Claims searched: all **Date of search:** 20 July 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H1Q (QAA,QAX, QKC, QKE, QKX)

Int Cl (Ed.6): H01Q (1/24)

Other: Online WPI EPODOC PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2288073 A	Motorola (see whole document esp fig 4)	1, 2 , 3
X	GB2257838 A	Technophone (see whole document)	1-17
X	WO 98/09342 A	Telefonaktuebolaget (see whole document)	1 at least
X	EP 0511577 A	Simens (see whole docuent esp fig 1)	1 at least
X	EP 0508567 A	Shaye (see whole document)	1 at least
X	US 5703602 A	Casebolt (see whole document)	1-17
X	US5504494 A	Chatzipetros (see whole document)	1, 2, 3
X	US 5255011 A	Tamura (see whole document esp fig 1a)	1 at least
X	US 5030963 A	Tadama (see whole document)	1 at least

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